

The XVIIth century: Carlo Fontana's expertises

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Carlo Fontana was an architect and writer who lived between the XVIIth and the XVIIIth century. He was born near Como in 1634 and died at Rome in 1714. He worked for some of the most important architects of the high baroque period: Rainaldi, Cortona and Bernini and he built his principal works in Rome: the Ginetti chapel at Sant'Andrea della Valle; the Cibo chapel in Madonna del Popolo; the cupola, great altar and ornaments of the Madonna de' Miracoli, the church of the monks of Santa Marta; the façades of the church of Beata Rita and of San Marcello in the Corso; the sepulchre of Queen Christina of Sweden in St. Peter's; the palaces Grimani and Bolognetti; the fountain of Santa Maria in Trastevere and that in the piazza of St. Peter's which is towards Porta Cavallegieri. He also built the dome of Santa Margherita in Montefiascone and sent a model for the cathedral of Fulda and to Vienna for the royal stables. He repaired the church of Spirito Santo de' Napolitani and the theatre of Tordinona and sent plans for the Jesuit church and college in Loyola, Spain. His nephews Girolamo and Francesco Fontana assisted him in all these works (Poole, 1909).

Fontana also published works on the Flavian Amphitheatre, the Aqueducts and the inundation of the Tiber. But the most famous work was *Il Tempio Vaticano e sua origine*, a diffuse description of the basilica of Saint Peter, published in 1694 by order of Innocent XI. Fontana included some geometrical rules for the construction of simple domes in this book, and analysed the stability of the dome of Saint Peter's with

geometrical and non-scientific tools (Straub 1952; Huerta 1990). These rules were a synthesis of the traditional knowledge about the construction of domes



Figure 1
Central façade of the cathedral of Santa Margherita in Montefiascone (Hager 1975)

and were used along the XVIIIth century. This paper deals with the previous work done by Fontana. He measured several domes at Rome and studied the architectural treatises to find geometrical rules and fixed proportions between the general dimensions and the width of the drum and the dome at the springing and at the top. And he mentioned this work in the context of several expertises about domes (Hager 1973,1975). It is possible to understand the evolution of the thinking of Fontana about the matter and his practical knowledge about the reinforcement of domes and their stability. The influence of the contemporary theory about the construction of domes is also present in these expertises.¹

THE DOME OF THE CHURCH OF SANTA MARGHERITA IN MONTEFIASCONI

The idea of building the cathedral of Santa Margherita in Montefiascone started at the end of the XV century

to provide a bigger and fitting place for Santa Margherita's remains. The works did not start until the beginning of the XVIth century, when the famous architect Michele Sanmicheli, superintendent of the works at the Cathedral of Orvieto, was in charge of building the cathedral of Montefiascone. Sanmicheli designed a church covered with a dome, but he finished his project until the drum and the church was covered with an ordinary roof because of lack of money, Figure 2. In 1670 a fire destroyed the roof and the interior of the church. Cardinal Altieri decided to build the dome and so, Carlo Fontana was in charge of building the dome, with 115 palms (34 m).²

In 1673 the dome was finished and Carlo Fontana wrote an expertise titled «Dichiaratione dell'operato nella Cuppola di Monte Fiascone colla difesa dalla censura.» He gave two projects, but after built it there were criticism because of the «excessive» width of the dome and the lower part of the church, Figures 3 and 4. The document, written in two chapters, is very interesting, because of the theoretical principles that

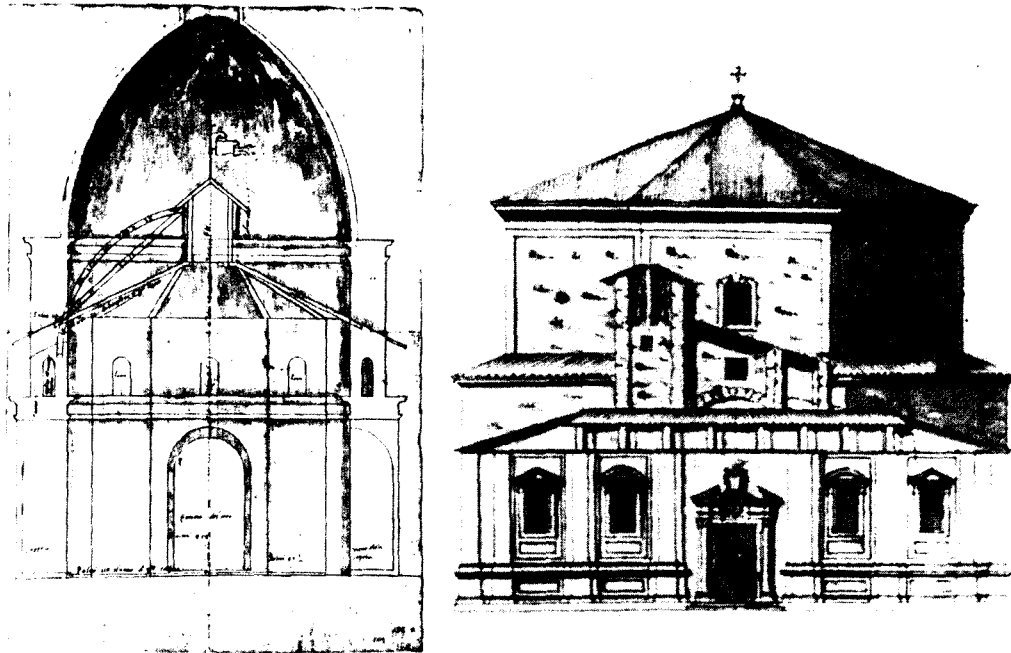


Figure 2

On the left, Melegghino's elevation, building survey and design for the temporary roof of the Cathedral of Montefiascone (Ost 1970). On the right, elevation of the cathedral of Santa Margherita until 1670 (Fontana 1673)

gave the author, mainly in the second part. He tried to justify the dimensions of his project with the measurements of the dimensions of different domes and the geometrical rules or rules of proportion of practical use contained in the treatises.

First chapter

In the first part of the expertise, Fontana explained the first steps he made before designing his projects. He made a survey of the walls and the foundations with the architect Angelo Torroni and the master builder Simon Brogi.

Fontana found that the height and width of the walls were enough to sustain the dome and they did not show cracks. The soil had a great resistance and the small cracks in the church had been caused by the settlements of the masonry elements, natural in this kind of buildings in the first stages of the construction. The old building was safe enough to support the new dome.

After surveying the old construction, Fontana studied the existing domes at Rome, whose proportions he measured «from the bottom, to the Lantern».³ In the second chapter he will describe these measurements in a detailed way. In this part Fontana described the materials and geometry of the domes. The materials, brick or stone, determined the proportions:

The domes described, made of brick, indicated me a greater width for the mentioned of Montefiascone, rebuilt with a wall of stone, that for being equal to the brick wall, stronger and with more durability, would have need a double width . . .⁴

Besides the material, Fontana believed that the proportions depended on the fact that there was a drum or the dome rested directly upon the main arches. The dome of Montefiascone would rest upon a drum, while the studied domes did not have drum, so, because of this feature that one would need a double width that he had proposed.

When the first proposal of Fontana was accepted he asked for the «exactness» of the dimensions, because «at first sight one can imagine a different width in the built parts».⁵ Figure 3. In the second and final project, Fontana only made qualitative changes, Figure 4. In this part of the expertise Fontana made interesting

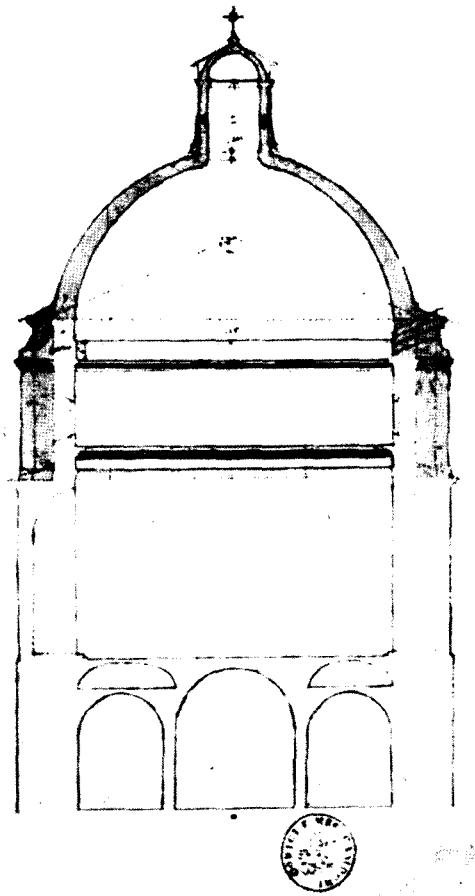


Figure 3
First project of a simple dome for Santa Margherita (Fontana 1673)

statements from the structural point of view. He proposed the construction of eight ribs, «that resist the violence of the winds».⁶ There were piers around the drum as a prolongation of the ribs in the dome. A simple cylindrical drum «would be more expensive because of the rings that should be placed instead of the ribs».⁷ The niches between the piers were curved, and that was «the reason why they strengthen the whole building and resist the thrust of the dome . . .».⁸

At the end of the first chapter, Fontana explained that the dome was built with stone because there were no bricks in that area and the building works would

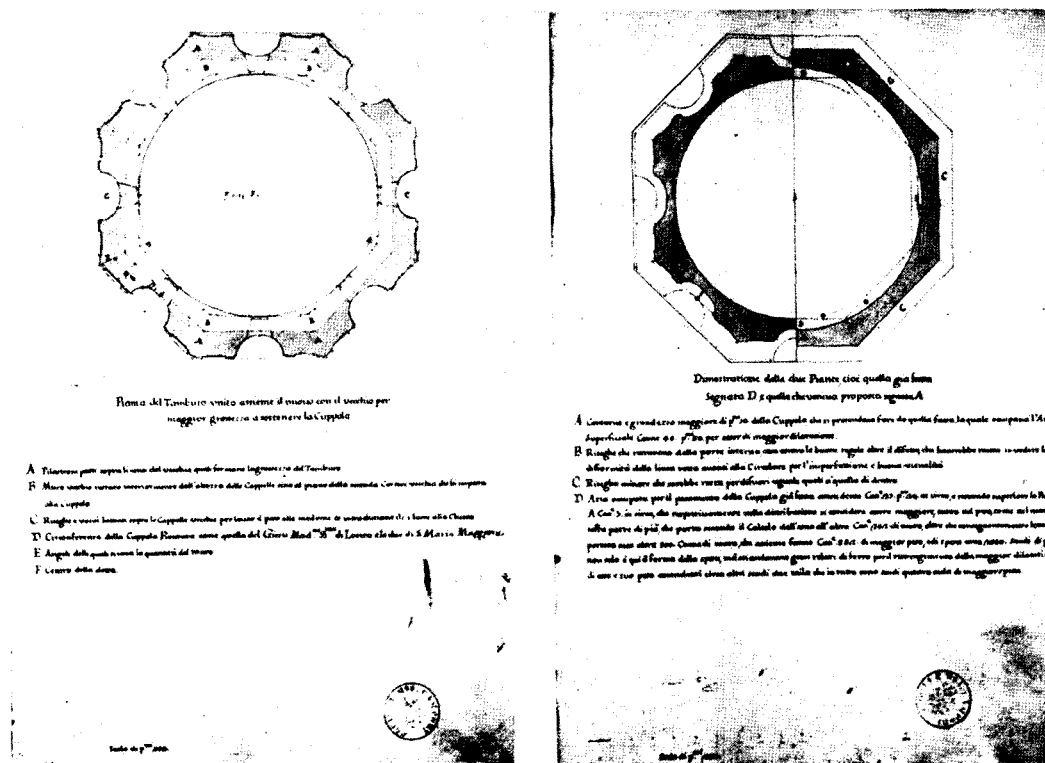


Figure 5
Plans at different levels of the cathedral of Santa Margherita (Fontana 1673)

the one at Santa Maria di Loreto, built by Bramante, Figure 6.

As for the shape of the dome that some critics would build with a more pointed shape he answered. «I do not have taken away from the rules of Vitruvio, Palladio, Vignola, Scamozzi, Serlio and Leon Battista Alberti.»¹²

Rules, reasons and examples.

At the end of the expertise, Fontana described the examples and theoretical principles on which he based his argumentation. First, he gave information about the dimensions of five domes at Rome, which he measured by himself. Also he included a table with the results of calculating the dimensions of the dome of Montefiascone if it had been built with the same

rule of proportion of every dome described, that is to say, the width of the wall at the springing and on the top of the dome for a span of 115 palms.

Fontana modified in the table these measurements to take into account the material and the structural system and not only the span of the dome. Fontana concluded that the dome of Montefiascone had not an excessive width compared with the width it had to be if it were built according to these rules of proportion.¹³

His argumentation was also based on the architectural treatises. He applied a Vitruvian rule to explain a geometrical way to determine the dimensions of the dome of Montefiascone, Figure 4. He compared in a drawing an ideal simple dome and the proportions according to Vitruvio, Palladio, Bramante, Serlio, Alberti and Scamozzi, Figure 7. And he deduced the proportion between the span and

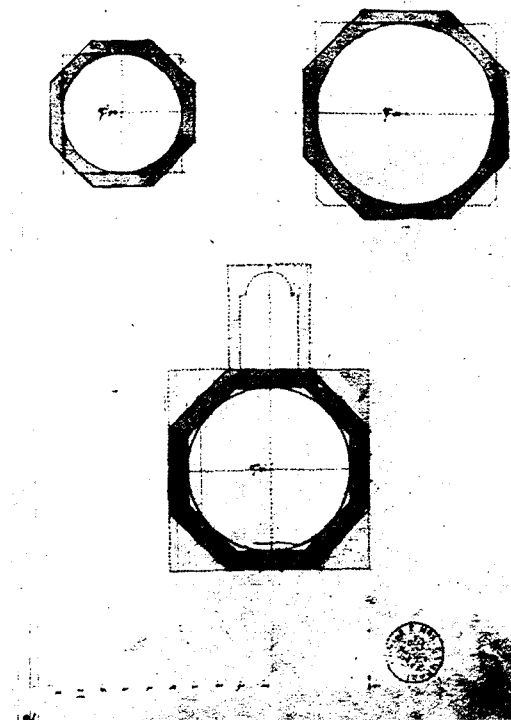


Figure 6
Plans of the domes of Santa Maria Maggiore, Il Gesù and Santa Maria di Loreto (Fontana 1673)

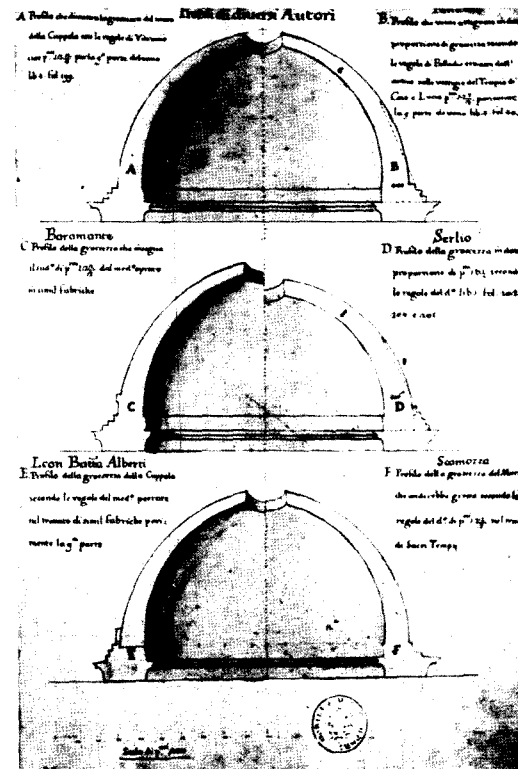


Figure 7
Comparison between sections of simple domes according to different architectural treatises (Fontana 1673)

the width of the base of the dome of Montefiascone if it had been built following each author. The real width of the dome of Montefiascone was always smaller than the dimensions obtained applying the rules of proportion proposed by Vitruvius (1/9), Serlio (1/7), Palladio (1/9), Alberti (1/9).

Fontana made a demonstration based on his own experience and on the treatises that the damages in the dome of Montefiascone were not caused by a bad design or excessive weight.

THE DOME OF SANTA MARIA IN VALLICELLA, ROMA

The church of Santa Maria in Vallicella, known also as Chiesa Nuova, rose on the site of an earlier church called «in Vallicella», because it had stood in the valley of a small stream flowing into the Tarentum

marshes. The area was very disagreeable because of the stagnant waters, sulphurous odours and damp mists, and probably there was even a cavernous hole. The pre-Republican Romans thought it covered the Gates of Hell and so, they built a temple in honour of two important underworld deities, Dis and Proserpina. Some of the marbles and statuary of the pagan temple discovered in the XVI century were reused or sold in the new church.

In the XVI century, St. Philip Neri replaced the original Santa Maria in Vallicella supposedly founded by St. Gregory the Great in the sixth century by a new and bigger construction, according to the plans by Mateo da Città di Castello and Martino Longhi the Elder. Gregory XIII and important Roman families helped St Philip to build the church. He

Table I
Proportions of the dome of Santa Margherita according to different domes (Fontana 1673)

Da Carlo Fontana, Architetto				in qualità	in costruttura	
<i>Cuppole diverse di Roma</i>	<i>Cuppola di Monte Fiascone</i>					
<i>Cuppola del Gesù fuori</i>	Di uano p.mi 115 in data	Muro da	nella	p.mi	p.mi	presente
ortangolare dentro tonda di uano	pro portione producono in uirtu	pedi	Cima	15	18	grosso
p.mi 80.g.a p.mi 6 nella cima	delle dette Cuppole le seguenti	p.mi	p.mi 4½	manca	manca	p.mi
p.mi 2½ mattoni	grossezze	9½	manca	p.mi 6½	p.mi 9½	8½
			p.mi 1			
<i>Cuppola di S. Andrea della Valle</i>			manca p.mi		manca	manca p.mi
Di uano p.mi 78.			2½		p.mi 11½	16
g.a p.mi		p.mi	p.mi	p.mi	p.mi	
7½ e nella		11½	7	20	25	
Cima p.mi 5						
<i>Cuppola di S. Agnese</i>			manca		manca	manca
Di uano			p.mi 4½		p.mi 13½	p.mi 19½
p.mi 58.		p.mi	p.mi	p.mi	p.mi	
g.a p.mi 7 nella cima		13	7½	22	27	
p.mi 4 mattoni						
<i>Cuppola della Chiesa Nuova</i>			manca		manca	manca
Di uano			p.mi 5½		p.mi 13½	p.mi 21½
p.mi 62.						
g.a p.mi 7		p.mi	p.mi	p.mi	p.mi	
nella cima		14	9	22	30	
p.mi 5 mattoni						
<i>Cuppola di S. Carlo a Catenari</i>			cresce		manca	manca
Di uano			p.mi ½		p.mi 4½	p.mi 10
p.mi 72		p.mi	p.mi	p.mi	p.mi	
g.a p.mi 5		8½	5½	13	19	
nella cima p.mi 3 mattoni						

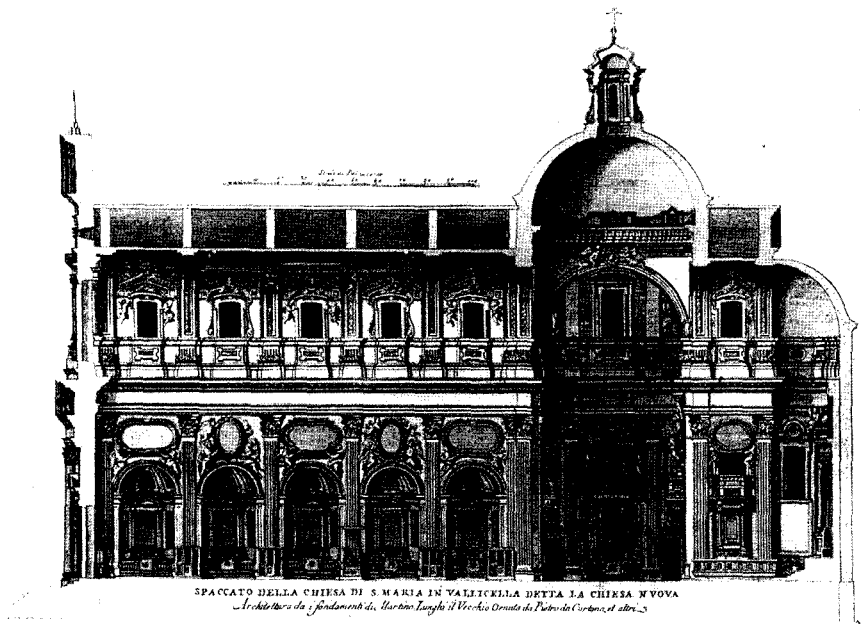


Figure 8
Longitudinal section of the church of Santa Maria in Vallicella, known also as Chiesa Nuova by D. De Rossi in 1721 (Conforti 1997)

fought against illiteracy and used new methods to evangelise children, pilgrims, based on music and Italian language instead of Latin. In Philip Neri's days, the church was known as «the joyous house». Work continued from 1575 until 1583. Faustolo Rughesi completed the façade in 1605.

The Oratorians' church is very similar to other Counter Reformation churches in Rome. It has a Greek cross plan, with a huge hall-like nave, a shallow apse and five lateral chapels, with a double-storied tripartite façade with scrolls.

The dome, which covers the altar, is a hemisphere, with lantern and rests upon a very low drum. Giacomo Della Porta, following the original design of Martino Longhi built it between 1575 and 1599. Borromini put the lead on the roof in 1643. In 1650 Pietro Da Cortona was in charge of the decoration of the inner surface of the church with its paintings, also the inner dome. Da Cortona asked permission for increasing the size of the windows on the lantern to get a better lighting of his paintings. So he built a higher lantern with more weight than the previous one. At the same time he reinforced the dome with a false drum to support the increased weight of the lantern. In 1675, twenty-five years later, the cracks on the dome and the central vault, mainly on the dome, alarmed Roman citizens. Several architects and masterbuilders were asked for their opinion. The architects decided to write an expertise: Mattia de Rossi, Carlo Rainaldi, Carlo Fontana and an anonymous architect. Moreover it has been preserved a memory of the first meeting and another one by Sebastiano Resta where the cracks were described, Figure 9. Finally, a single ring was placed around the dome on the top of the drum and this protected the paintings of Da Cortona that would have disappeared if the dome would be rebuilt.

Fontana's expertise. Analysis of the dome and its proportions

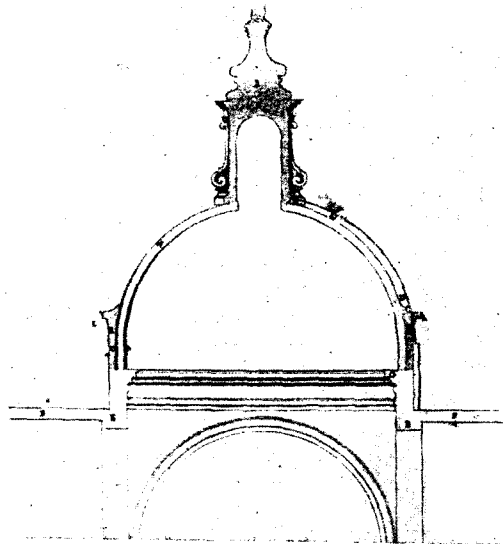
Carlo Fontana wrote an expertise about Santa Maria in Vallicella, two years later than he wrote the one about Santa Margherita in Montefiascone. In the first part, Fontana analysed the proportion of the main structural elements: foundation, piers, arches and dome. The four main arches had not severe damage, so he deduced their dimensions were correct, and that



Figure 9
Plan of the longitudinal nave and dome with a description of the cracks by Resta (Hager, 1973)

the piers were vertical and without settlement. If not, «these arches would be cracked, and changed their shape».¹⁴ The good condition of the foundation was also a reason to consider that the dimensions of the piers were correct. So, the origin of the cracks was in the dome itself.

Fontana gave quantitative information. As in the expertise about the dome of Montefiascone, he compared the proportions of the dome of Santa Maria in Vallicella with other domes at Rome. So, he measured an insufficient width of the walls upon the dome rested, only 2 palms (0,4468 m), that is, 1/30 of the span, with 65 palms (14,5 m). He compared it with the good rules of proportion for this kind of buildings «the width at the base is usually 1/12 of the diameter, that is, nearly 6 palms and at the top, 1/18 of the diameter, that is, 3 1/3 palms»,¹⁵ Figure 10.



2. The project was uncompleted. So the wall looked like no definitive and showed thinner areas, mainly near the façade, also with cracks.

The third origin of the cracks, and more important according to Fontana, was the bad quality of cement, a faulty of execution or that the masonry would have suffered the climate effects during the execution. Moreover, the masonry contained a percentage of cement of 50%.

The lantern and the basement

Although the reasons considered would be quite important to cause damage to the dome, there was another one: the great weight of the lantern compared with the weight of the dome. This weight caused also damage to the lantern's oculus.

On the other side, the supporting wall of the dome, actually a false drum, was weakened by the oval windows. Furthermore, the height of the wall above the springing of the dome was not great enough, because «the thrust acts in the middle o at least at $1/3$ »,¹⁶ that is, there was no wall in the area where according to Fontana the thrust acted.

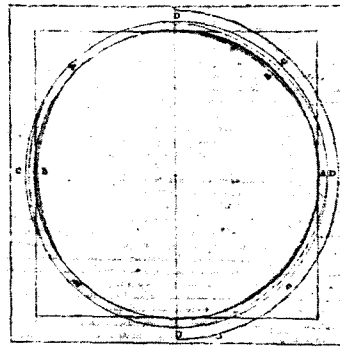


Figure 10
Analysis of the width of the false drum over the dome of Chiesa Nuova rests (Fontana 1675)

Fontana also discovered that the plan of the dome was not a perfect circle, that is, the wall upon which it rested, presented a variable width along the perimeter. This feature and its insufficient width according to the rules of proportion led him to state two hypotheses:

1. The builders had little ability, or

The cracks

There were two cracks on the dome, in the nearest area to the façade that tended to converge in the oculus, Figure 9. This sector of the dome had moved from the remaining parts towards outside, and this added weight to the neighborhood arches.

Although Fontana did not give quantitative data about the cracks, he observed that they progressed daily. After being painted, the damage had increased double.

The rings

Fontana suggested the conditions to make the repairs effective. The wall must be in very good conditions to put in the chains. Otherwise these could damage the fabric. Fontana distinguished several types of chains by the way of place them and explained their structural behaviour:

The chains are of different types, so they have a different essence, that is, resistance and stability; laid horizontal or perpendicular, or even oblique, . . . nobody could tell that they are not useful, but depending on the cases and materials.¹⁷

He also explained that the chains must be placed «in the third of the *Sesto*».¹⁸ But he insisted on the importance of improving the quality of the construction, of reinforcing it in the key places and increasing the width of the drum wall.

Three proposals of reinforcement

Before explaining his three proposals of intervention he explained the way of propping up the dome.¹⁹ Once propped up the lantern the weight could be

reduced with no hurting tools. Later Fontana proposed three projects, Figures 11 and 12. In all of them, Fontana wanted to increase the width of the drum and place rings.

In the first proposal, the width of the drum would be increased by means of an octagonal exterior wall, with stairs in the upper part, where two rings would be placed. Also the weight of the lantern would be reduced.

If it would be necessary, Fontana proposed the construction of a double dome with eight ribs, similar to the dome of Saint Peter's and Santa Maria di Loreto, at Rome. Here, he proposed three rings, one of them to be placed in the external shell of the dome, Figure 11.

In the third project, Fontana proposed the construction of eight reinforcing ribs D, Figure 12,

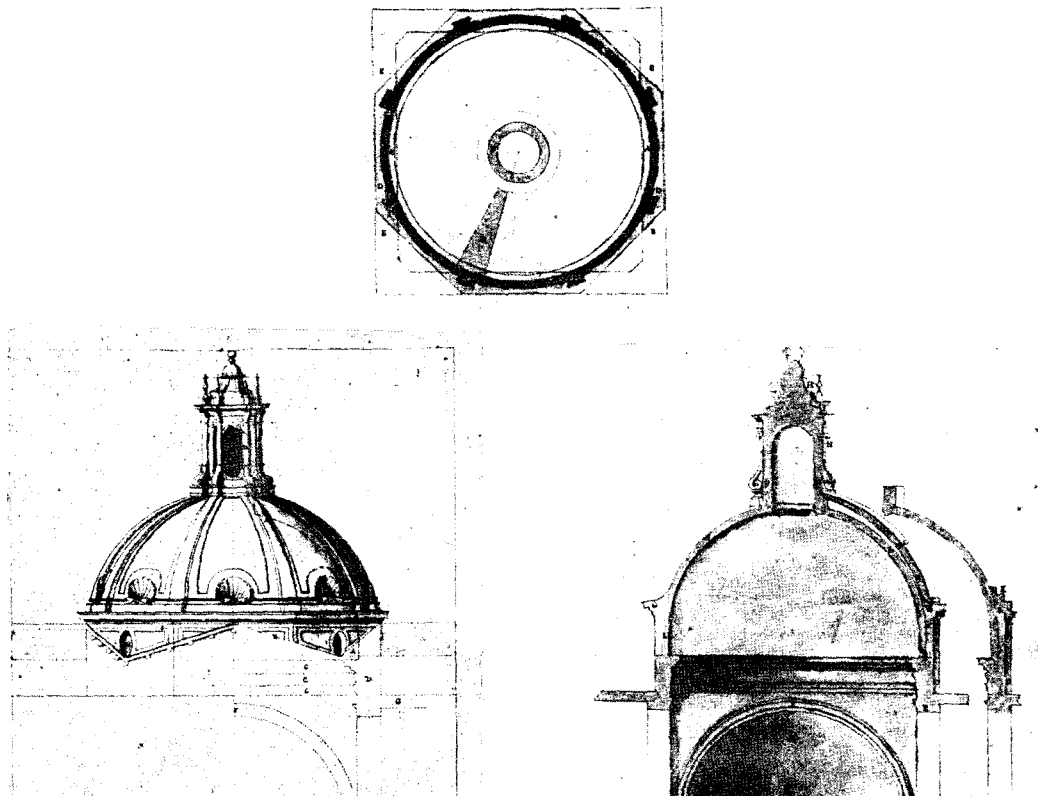


Figure 11
First and second project of Fontana (Fontana 1675)

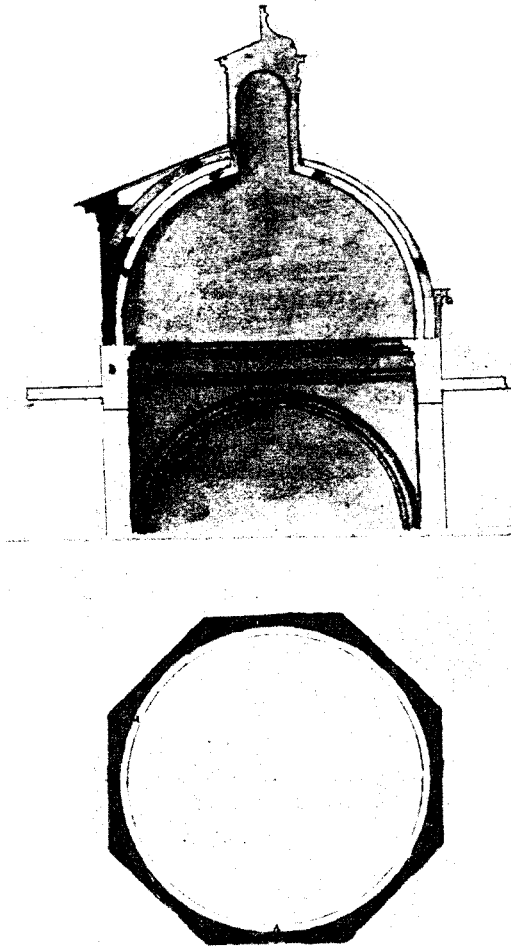


Figure 12
Third project of Fontana (Fontana 1675)

which would transmit the thrust to a reinforced drum «until medium height, where it has a greater thrust, in the *Sesto*, where three rings are to be placed to resist it».²⁰

The octagonal drum would be going beyond the springing of the ribs, and this would help counter part the thrusts with its weight. Also the weight of the lantern would be reduced. A sloped roof would cover the dome with the reinforcement.

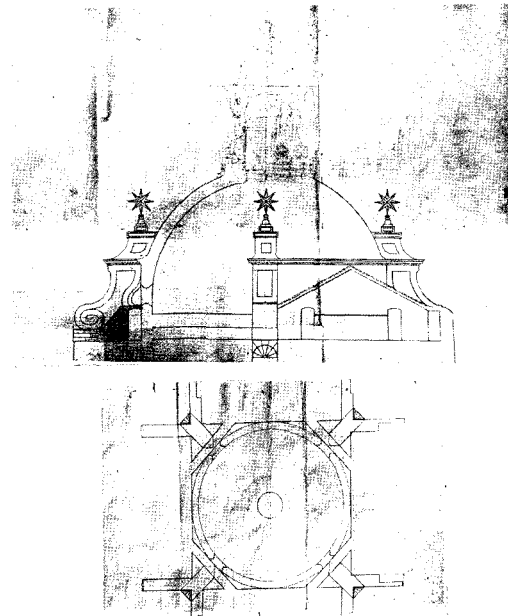


Figure 13
Anonymous project for reinforcing the dome with four buttresses (Hager 1973)

CONCLUSION

Fontana's rules proposed in *Il Tempio Vaticano e sua origine* would be the final stage of his research about domes that developed along nearly twenty years. His rules were based on the architectural treatises that represented the written tradition about masonry domes, and on his own surveys and measurements of real domes. These rules were not only geometrical, but they were the result of his practical work and they took into account the constructive features of the buildings.

Fontana's expertises are also a proof that the theory of masonry domes developed in connection with the need to study cracked domes and repair them. An expertise is a written document where the architect must justify the safety of a real structure and propose a way to repair or reinforce it, and so we can know now something about the way of thinking in the XVIIth century about the construction of domes.

Fontana's rules were a link between the tradition and the scientific theories that would be developed

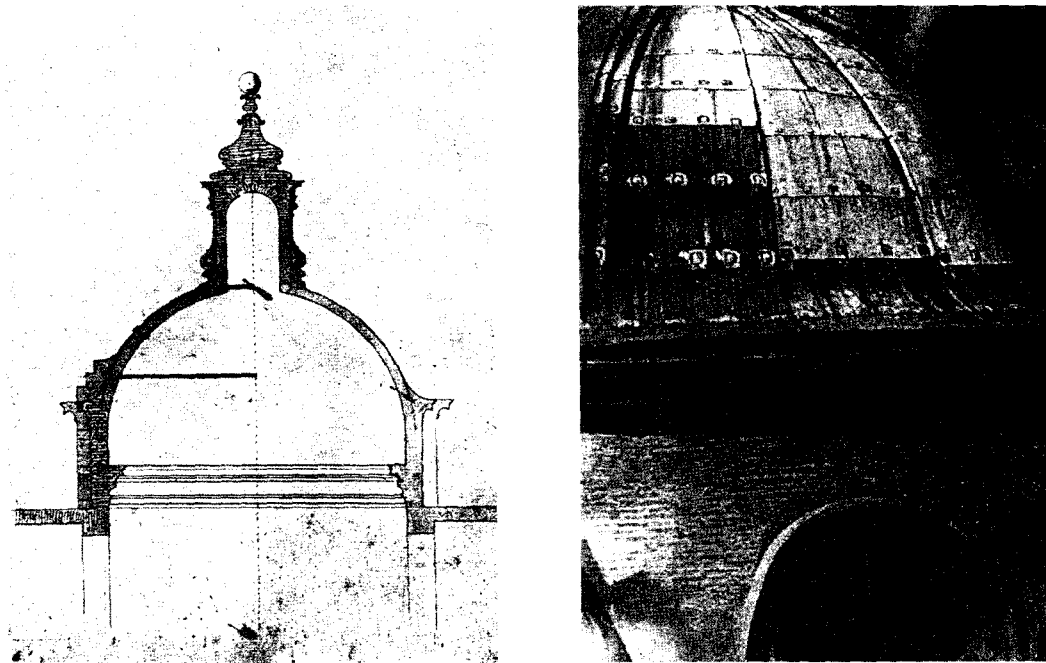


Figure 14
Project of M. De Rossi and the ring placed around the dome (Hager 1973)

during the XVIIIth century and they would serve as practical rules for practitioners and theoreticians until the XIXth century.

NOTES

1. Only Hager (1973 y 1975) mentioned the existence of these expertises (he reproduced them in his articles), although he did not analyze their structural and constructive significance nor their importance to understand the work done by Fontana about the theory of domes. Falconieri (1695) and later Poleni (1748), who mentioned Falconieri, referred the cases of the dome of Montefiascone and of Chiesa Nuova. According to Falconieri Fontana gave him information about both domes and repaired them with rings, but he did not mention in his manuscript Fontana's expertises nor their relation to Fontana's rules. (Fontana did not mention any ring to place in his own expertise. Perhaps he decided to put the two rings that can be seen today some years later). The rules proposed by Fontana in *Il Tempio Vaticano e sua Origine* (1994) have been
- analyzed by Straub (1952) and Huerta (1990), who has demonstrated their validity from the point of view of the Limit Analysis theorems. About the expertises described in this paper see also López (1998).
2. The Roman palm contains 12 ounces = 0, 2234 m. See Parsons (1976), 629.
3. « ... al loro nascimento, sino al Lanternino ... » Fontana (1673). Also in Hager (1975), 165.
4. « ... le descritte Cuppole fatte di mattoni, mi prometteuano grossezza maggiore nella detta di Montefiascone, riformata con muro di Pietra, il quale per uguagliar quello di mattoni, assai più forte, e perpetuo di questo, hauerebbe portato duplicità di grossezza ... » Fontana (1673). Also in Hager (1975), 165.
5. « ... che dalla semplice veduta tal uno s'inganna immaginandosi forse diuersità di grossezza nell'operato, dico, che dal primo al secondo profilo, qui accluso restando nella quantità hò: solamente variata la qualità ... ». Fontana (1673). Also in Hager (1975), 166.
6. « ... che repugnano alla violenza de venti ... » Fontana (1673). Also in Hager (1975), 166.
7. « ... che hauerebbe portato spesa maggiore per uoler colle catene ottener l'effetto, che partoriscono li Costoloni. » Fontana (1673). Also in Hager (1975), 166.

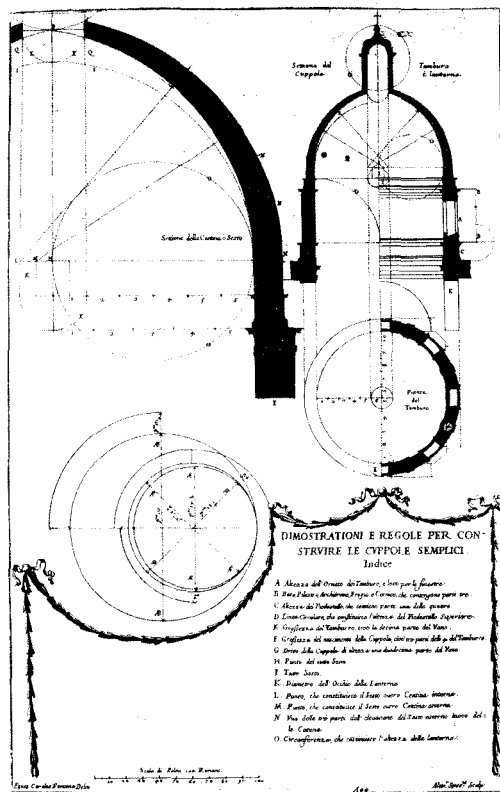


Figure 15
Geometrical rules for the construction of simple domes
(Fontana 1694)

8. «... per la qual causa partoriscono vigore al corpo della Machina, e contrastano col spingimento della Cuppola, hauendo attiuittà basteuole per la proportion del Muro tolta dal vano delli finestroni, e portata al viuo delli detti Pilastroni, li quali così assicurano l'Arco in virtù della lor grossezza.» Fontana (1673). Also in Hager (1975), 166.
9. This stone was volcanic and so, lighter, according to Marconi (1997), 231.
10. «... pelo perpendicolare alto p. mi. 12 in circa ... » Fontana (1673). Also in Hager (1975), 166.
11. «... trauersali, et irregolati ... » Fontana (1673). Also in Hager (1975), 166.
12. «... Io non mi sia allontanato dalle regole di Vitruvio, Palladio, Vignola, Scamozzi, Serlio, e Leon Battista Alberti.» Fontana (1673). Also in Hager (1975), 166.
13. I have deduced from these dates that Fontana increased the width of the wall in two thirds to take into account the material, brick, and later in one fifth to consider the drum. So the final width of the wall at the springing would be twice the width deduced of the rule of proportion of each dome. The real width of Montefiascone was smaller than these quantities and so the dome lighter compared with the traditional rules. In 1694 he established the width of the dome at its base as $\frac{3}{40}$ of the span and advised the architects to build the drum of the simples domes made of brick with a width of $\frac{1}{10}$ of the span, and the domes made of light stone, with a width of $\frac{1}{9}$ of the span, like in Montefiascone's drum (already built when Fontana was in charge of the project of the dome). This means that he reduced the width that the treatises advised for the base of the dome ($\frac{1}{9}$ of the span to $\frac{3}{40}$) and proposed lighter domes with a modified profil or structural elements like the ribs.
14. «... che nelle tangenti della Cornice come parte più debole, & loco della Diuisione delle Quattro forze, si trouano saldi, e senza motiui di peli considerabili ... si uedrebbero aprire detti archi, riducendoli fuori del proprio Sesto ... » Fontana (1675). Also in Hager (1973), 314.
15. «... sogliono esser le lor grossezze nel nascimento circa la duodecima parte del Diametro, cio è palmi 6. scarsi, e nel finimento la Decima ottaua parte del medemo cioè Palmi $3 \frac{1}{3}$... » Fontana (1675). Also in Hager (1973), 314. Fontana referred to the width of the dome at the springing, not to the width of the drum.
16. «... lo spingimento è fra la metà dell'elevatione, ò almeno il 3.o ... » Fontana (1675). Also in Hager (1973), 315.
17. «Sono Catene di varij Generi; onde diuersificano nel loro essere, cio è fermezza, & immobilità poste Orizionalmente, ò perpendicolarmente, o uero obliqui, non si nega, che ogn'uno di questi non possa fare qual che effetto, mà secondo i Casi, e le Materie.
In che venendo alle Catene, due forze da loro si riceue, che sono mantenimento, e solleuamento, pur che ui sia fermezza nelli dui punti principio, e fine, secondariamente ui è poi la Circolare, che in se costringe nel proprio luogo un corpo sferico.
... e le Oblique sono aliene delle dette due forze, cioè Perpendicolare, e Orizontale in ordine al suo proprio genere, sono fuori delle terminationi rette, per essere parte di un Circolo, come materialmente si uede da un pezzo di un Cerchio di qualsiuoglia materia premendolo nelli due lati, ò punti, s'inarca, e stirandolo si adriizza, Dunque concesso, che sia costituito sopra una base soda, e eretta in elevatione la parte piegata attenderà sempre al suo Centro, e si renderà nella Cima immobile.» Fontana (1675). Also in Hager (1973), 315.

- It could be deduced from these words that Fontana meant the rings exert centripetal forces because of their circular shape. So, when their position is completely horizontal they are not able to resist vertical forces, mainly when the weight is too big, as it is the case of a horizontal ring put around the base of the lantern.
18. «... nel terzo del Sesto...» Fontana (1675). Also in Hager (1973), 316.
 19. «Sarà necessario fare il Ponte Reale alle imposte della Cuppola di dentro con corde abbili à sostenere le incavallature Zoppe, che anderanno à ferire sotto il Lanternino per riceuere sopra di se il proprio peso per diuertimento nella propria cuppola, acciò concedi più facilmente la perfetta operatione di ritorno, sopra le quali con uarij sbadacci, ò forze Diagonali, che medemamente anderanno à ferire doue sono le parti relassate.» Fontana (1675). Also in Hager (1973), 316. From the text of the expertise it is possible imagine a propping system with tension and compression members.. The propping system would make possible to survey the drum.
 20. «C. Refianco quasi a mezza eleuatione, doue fa la maggior forza nel Sesto, nel quale ui si pongono tre Catene per resistenza della medema.» Text from the figure 12. *Spaccato del progetto per ridurre il peso della lanterna e di sostenerla con otto sostegni (D) fondati su un tamburo ottagonales da costruire e nascosti sotto un tetto pendente*. Fontana (1675), Fol. 41. Also in Hager (1973), 310.
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- REFERENCE LIST**
- D'Amelio, M. Grazia; N. Marconi. 1997. «Le cupole del XV e XVI secolo a Roma e nel Lazio. In *Lo specchio del cielo*, 135. Milano: Electa.
- Falconieri, P. 1695. «Discorso sopra la Cupola di S. Pietro, fatto a requisizione dell'Illustrissimo Signor Paolo Falconieri in Agosto, 1695.» MS. 5534, Biblioteca Nazionale, Venecia.
- Fontana, Carlo. 1673. «Dichiaratione dell'operato nella Cuppola di Monte Fiascone colla difesa della censura». *Discorsi e Dichiarazioni*, MS. g B. 1. 16, Fondo Gius. Campori, 379, Biblioteca Estense, Módena.
- Fontana, Carlo. 1675. «Discorso sopra le cagioni onde deriuano li difetti che giornalmente si scorgano nella Cuppola o Volta della Chiesa Noua di Roma & per li proposti rimedij al suo bisognoso riparo». *Discorsi e Dichiarazioni*, MS. g B. 1. 16, Fondo Gius. Campori, 379, Biblioteca Estense, Módena.
- Fontana, Carlo. 1694. «Regole per le Cupole Semplici, & effeti di esse, e dell'altre doppie». In *Il Tempio Vaticano e sua origine*, 361 ss. Roma: Stamperia di Gio. Francesco Buagni.
- Hager, Hellmut. 1973. «La crisi statica della cupola di Santa Maria in Vallicella in Roma e i rimedi proposti da Carlo Fontana, Carlo Rainaldi e Mattia de Rossi». *Commentari. Rivista di critica e storia dell'arte*. 24, 4: 300–318.
- Hager, Hellmut. 1975. «Die Kuppel des Domes in Montefiascone. Zu einem borrominesken Experiment von Carlo Fontana». *Römisches Jahrbuch für Kunstgeschichte*, 144–168.
- Huerta Fernández, Santiago. 1990. «Diseño estructural de arcos, bóvedas y cúpulas en España. ca. 1500 - ca.1800». *Ph. D.*, Universidad Politécnica de Madrid. Escuela Técnica Superior de Arquitectura.
- López Manzanares, Gema. 1998. «Estabilidad y construcción de cúpulas de fábrica: El nacimiento de la teoría y su relación con la práctica». *Ph. D.* Universidad Politécnica de Madrid. Escuela Técnica Superior de Arquitectura.
- Marconi, Nicoletta. 1997. «La teoria delle cupole nei trattati di architettura tra Seicento e Settecento». In *Lo specchio del cielo. Forme significanti tecniche e funzioni della cupola dal Panteón al Novecento*, edited by C. Conforti, 230–43. Milano: Electa.
- Ost, Hans. 1970. «Santa Margherita in Montefiascone: A Centralized Building Plan of the Roman Quattrocento». *The Art Bulletin* 52,4: 373–389.
- Parsons, W. B. 1976. *Engineers and Engineering in the Renaissance*. Cambridge, Mass.: MIT Press.
- Poleni, Giovanni. 1748. *Memorie istoriche della gran cupola del Tempio vaticano*. Roma: Stamperia del Seminario.
- Poole, Thomas H. 1909. «Carlo Fontana». *The Catholic Encyclopedia*. 6. (Online edition, 1999).
- Rainaldi, Carlo. 1675. «Parere di Carlo Rainaldi». Archivio di S. Maria in Vallicella, C. II. 8, fol. 79. (Reproduced in Hager 1973).
- Resta, S. 1675. «Memorandum del Padre Sebastiano Resta.» Archivio di S. Maria in Vallicella, Fábrica, C. I, 26, fasc. 35. (Reproduced in Hager 1973).
- Straub, H. 1952. *A History of Civil Engineering*. London: Leonard Hill.
- Tomasso, Francesco de. 1991. «S. Maria in Vallicella». In *Le cupole di Roma*, 92–93. Roma: La Meridiana Editori.